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Seasonal patterns in the abundance, size, and production of profundal Chironomidae in Starnberger See (Bavaria, FRG)

(Diptera, Chironomidae)

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Triplicate Ekman-Birge samples were collected at 3–4 week intervals during 2 years in the profundal of the mesotrophic Starnberger See. Data are presented on abundance, length distribution, biomass, and production of the predominant profundal chironomids *(Micropsectra, Sergentia, Tanytarsus)* of this lake.

Mean biomass (B), production (P), and turnover-rates (P/B) for the two-year period were: for *Micropsectra:* B 10.1 g/m^2, P 21.2 g/m^2, P/B 1.27, for *Sergentia coracina:* B 6.85 g/m^2, P 3.32 g/m^2, P/B 0.48, and for *Tanytarsus:* B 700 mg/m^2, P 421.4 mg/m^2, P/B 0.63. Biomass and production of profundal chironomid larvae are strictly connected with seasonal changes in the abundance, size, and phenology of the corresponding species.

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Introduction

There have been few studies of production of benthic invertebrates in prealpine and alpine lakes, but most of those that have been carried out involve the Chironomidae. This is probably due to their abundance, their importance as fish food, and as indicator organisms.

In this paper, I present data on length distribution, biomass, and production of the predominant profundal chironomids *(Micropsectra, Sergentia, Tanytarsus)* of the mesotrophic Starnberger See. These data are based on the results of the first long-term investigation of the profundal chironomid fauna of this lake (Gerstmeier 1989).

Methods

Limnological characteristics and detailed sampling procedures are also described in the papers of Gerstmeier (1985) and Lenhart & Steinberg (1982).

Starnberger See is situated about 25 km southwest of Munich (Bavaria). Sampling stations were located at various depths along two east-west transects (10 m depth intervals, from 30 to 70 m along the Bernried (Bernr) transect and from 20 to 80 m plus 100 and 120 m depth along the Garatshausen (Ghsn) transect).

Triplicate Ekman-Birge samples were collected at each station at 3–4 week intervals from April 1980 through March 1982. In addition, the 20 m station on the Garatshausen transect was sampled from August 1982 through September 1983, also at 3–4 week intervals. Samples were washed through a sieve of 220 µm mesh, and the remaining mud was processed using the sugar flotation method. The separated chironomid larvae were briefly rinsed in water and preserved in 70% ethanol. Body length and head capsule width were measured using an ocular micrometer or mm-ruled paper.

Only the Chironomini *Sergentia coracina* and the Tanytarsini *Micropsectra (M. contracta, M. coracina)* and *Tanytarsus (T. bathophilus, T. lugens)* occured in substantial numbers, therefore length measurements were restricted to these groups (Tab. 1).

For biomass calculation, live larvae were briefly blotted on tissue paper (Wiederholm & Eriksson 1977a), packed in staniol paper to avoid weight loss, and weighed with an accuracy of ± 0.1 mg.

The Tanytarsini larvae could not be identified to the species.

Length-weight relationships were calculated with two equations after Kohmann (1982):

1) $W = be^{mL}$ linear equation for 1) $\ln W = \ln b + mL$
2) $W = bL^{m}$ linear equation for 2) $\ln W = \ln b + m \ln L$

For *Sergentia coracina* Equation 1 gave better results (higher r^2), whereas for the Tanytarsini *(Micropsectra, Tanytarsus)* Equation 2 was better. Values for b and m are given in Tab. 2.

Production was calculated after Winberg et al. (1971):

$$P = \tfrac{1}{2}\,(Nt + No)\,(Wt - Wo)$$

where Nt and No are the final and initial numbers and Wt and Wo are the final and initial weights for each interval of time.

Results

Seasonal variation in the abundance of *Micropsectra, Sergentia* and *Tanytarsus*

The abundance of *Micropsectra* larvae shows a consistent annual pattern (Fig. 1a). Maximum densities of over 3000 larvae/m² occured in the spring of 1980 on both transects, and dropped to fewer than 100/m² through the winter.

In contrast, *Sergentia coracina* densities fluctuate between 100–400 larvae/m² throughout most of the study with no obvious seasonal pattern (Fig. 1b). Substantially higher abundances of this species occured toward the end of the study along the Bernried transect, with over 800 larvae/m² in February of 1982.

Larvae of the two *Tanytarsus* species varied considerably in abundance, not only seasonally but also between the two transects (Fig. 2). A maximum abundance of 237 larvae/m² occured in November along the Garatshausen transect.

Length distribution in *Micropsectra, Sergentia* and *Tanytarsus*

The distribution of *Micropsectra* larvae among four length groups – summarized over all depth zones – was unimodal for nearly every period (Fig. 3). Overwintering larvae were almost exclusively in length class 1. Growth was rapid from April through July and most larvae were in length classes 3 and 4 throughout the summer and autumn. Because *Micropsectra* larvae were scarce at 20 m, results from this depth are omitted.

The considerably larger *Sergentia* larvae were assigned to five length classes (Fig. 4). Contrary to the results obtained for *Micropsectra,* most distributions are bimodal. Most larvae were in the larger size classes by the end of winter. An increase in length class 1 was apparent in March 1981, and in February 1982, reaching a maximum value in April. Comparatively few individuals were present in May, by which time some of the larvae of length class 1 had entered length class 2. Most of this cohort had entered the final length class by the end of July. An increase in length class 1 was again apparent in July with maximum numbers occurring in September. This size class dominated until December in 1980 and until November in 1981.

At 20 m depth a continuous monthly growth displacement occurred from length class 1 in August, to length class 5 in January. No individuals of length class 1–3 were present in February and the beginning of March (M 1), whereas in May, length classes 3 to 5 were absent.

The length distributions of the *Tanytarsus* larvae are unimodal (Fig. 5). Larvae overwintered mainly as length class 1 and 2. Growth during the spring appeared slow with a major increase in length class 3 becoming apparent in June. Between them length classes 3 and 4 dominated until August when length class 1 began to dominate.

The average body length of the four larval stages was not depth dependent (Tab. 3).

Biomass and production

The seasonal changes in the wet biomass of *Micropsectra, Sergentia* and *Tanytarsus* are shown in Fig. 6.

Micropsectra biomass was high during the summer and low during the winter. The maximum biomass recorded was 35.7 g/m^2 in July 1980. The biomasses recorded from the Garatshausen transect were higher than those recorded from the Bernried transect.

Whereas *Micropsectra* showed a distinct biomass minimum during the winter months, such a pattern was not apparent for *Sergentia* (Fig. 6b). Maximum values (24 and 21 g/m^2, for Garatshausen and Bernried respectively) occurred in February 1982, minimum values (1.02 g/m^2) in May of both years. There were no consistent differences between the transects.

No clear pattern in the seasonal changes in biomass was discernible for *Tanytarsus* (Fig. 6c) either. The lowest biomass occurred in September (Garatshausen and December (Bernried). There were no consistent biomass differences between the transects.

Average larval wet weight is relatively uniform in *Micropsectra* and *Tanytarsus* (Figs. 7a, c). In *Sergentia* however, considerable fluctuations occurred (Fig. 7b): the larvae were heaviest in February/March and July/August, whereas minimum average weights occurred in May and in September/October. The patterns for the two transects are similar. An increase in average larval weight with increasing depth, as reportet by Kajak & Dusoge (1975a), was not observed for Starnberger See.

Since the average larval weights are nearly uniform for both transects and as more study periods are available for the Garatshausen transect, production calculations are restricted to this latter area (Tab. 4–6).

Maximum biomass was reached by *Micropsectra* in July, *Sergentia* in February, April, and by *Tanytarsus* in February, July and November.

A substantial fall in larval biomass occurs when the adults emerge giving negative production values. Maximum negative production occurred for *Micropsectra* in August, *Sergentia* in August, October, and by *Tanytarsus* in September, October.

The average cumulative production rates from April 1980 until December 1980 and February 1981 until November 1981, respectively, are 33.5 and 8.9 g/m^2 for *Micropsectra,* 5.7 and 0.95 g/m^2 for *Sergentia,* and 421 and −0.2 mg/m^2 for *Tanytarsus,* respectively.

The turnover rates (production/average biomass) are:

Micropsectra	P/B = 2.60 (1980) and 1.20 (1981)
Sergentia	P/B = 0.83 (1980) and 0.14 (1981)
Tanytarsus	P/B = 0.63 (1980)

Discussion

Biomass and production of profundal chironomid larvae are strictly connected with seasonal changes in the abundance, size, and phenology of the corresponding species.

Although a great number of papers on the biomass and production of Chironomid larvae are available (Banse & Mosher 1980), only few data are at hand for *Sergentia coracina* and for *Micropsectra* as well as *Tanytarsus* species.

The abundance of *Micropsectra* larvae showed a conspicuous minimum between October 1980 and April 1981 with a following maximum at the end of June, indicating a main emergence period in August and September. Length group 4 – that means larvae are nearly mature to pupate – were mainly found from June through October (Fig. 3), which indicates an extended emergence from July through October.

Seasonal variations in biomass (Fig. 6a) generally corresponded with fluctuations in abundance (Fig. 1a). Biomass decreased considerably by the end of August and negative production attained its maximum value (Tab. 4). This result is in harmony with phenology: larvae ready to pupate have evidently stopped their growth by August, the first larvae leave the benthal and production turns negative. The period preceding the maturing of larvae (June, July) is characterized by maximum biomass and maximum production. The average turnover rate for both years (2.6 and 2.1, respectively) is similar to the value given by Welch (1976) for "*Lauterbornia*" sp. (= *Micropsectra)* (P/B = 1.9). However, the P/B rate (4.13) of *Micropsectra contracta* from the alpine Gossenköllesee in Tyrol is more than twice as much (Pechlaner & Zaderer 1985).

The bimodal distribution of the length groups of *Sergentia coracina* (Fig. 4) indicates two cohorts: one emerging in late spring (April, May) and the other in autumn (September, October).

Biomass and production (Tab. 5) maxima were reached in February (1981) and April (1980). The average larval weight was highest in February/March and April (1980). This corresponds with the spring emergence (negative production in April and May). Larval growth (no production) evidently ceases by the end of February.

Negative production by the end of August and in September 1981 indicates the second emergence phase during the autumn. Emergence is followed in both years by an increase in biomass and production in October and November (also in December 1980).

The average production of 3.3 g/m^2 in both years is slightly higher than the value 2.3 g/m^2 in the Norwegian Langvatn, an oligotrophic lake (Aagaard 1982).

Length groups 3 and 4 of both *Tanytarsus* species reach their maxima in August 1981 (Fig. 5) and emergence appears to occur mainly during late August and September.

The maximum negative production (Tab. 6) of *Tanytarsus* occurred in September and October, combined with the main emergences of the two species. This emergence was immediately followed by a rise in biomass and production.

Potter & Learner (1974) gave an average biomass of 320 mg dry weight/m^2 for *Tanytarsus lugens*. According to Dermott & Paterson (1974), larvae with a wet weight of 0.8 mg retain only 18 % of it as dry weight. The converted average value of 126 mg dry weight/m^2 for Starnberger See is considerably lower than that in the shallow, eutrophic reservoir in South Wales.

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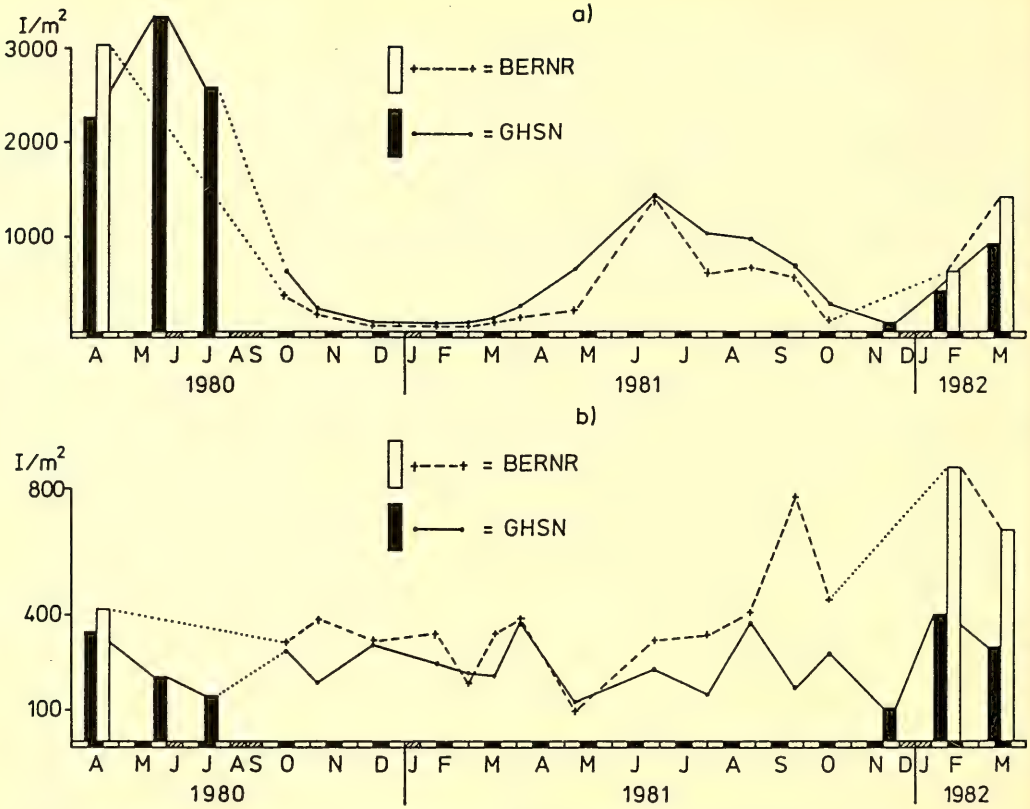

Fig. 1. Seasonal average abundance: a) *Micropsectra,* b) *Sergentia coracina.* Since merely three months (resp. two) could be investigated for the first half of 1980 (resp. 1982), these results are presented as histograms, in contrast with the more (– – – , ——) or less (. . .) continuous data from October 1980 to October 1981.

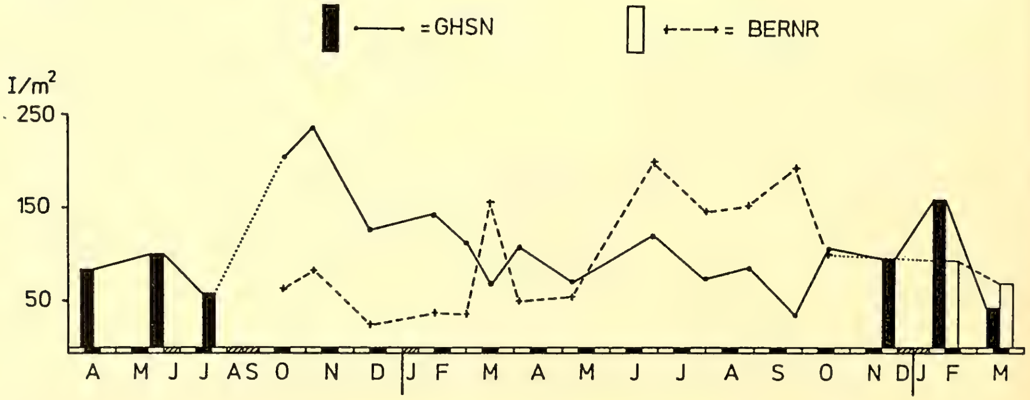

Fig. 2. Seasonal average abundance: *Tanytarsus.*

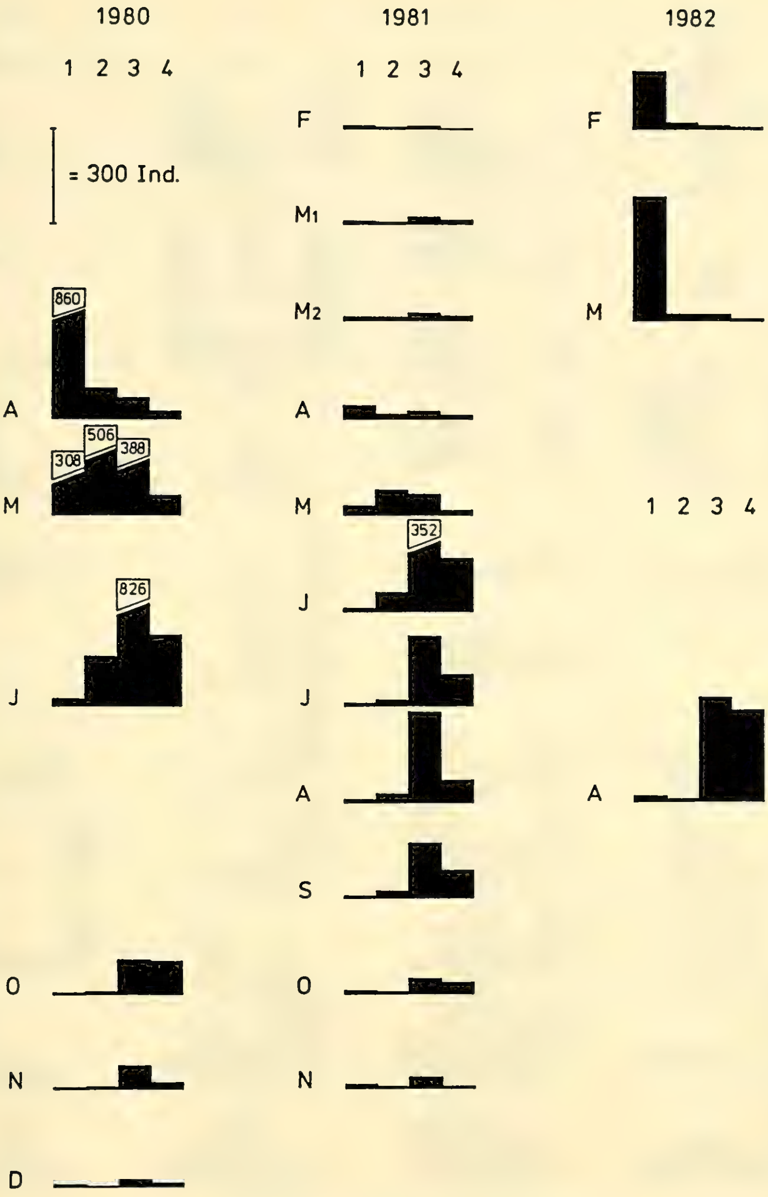

Fig. 3. Distribution of length classes: *Micropsectra*.

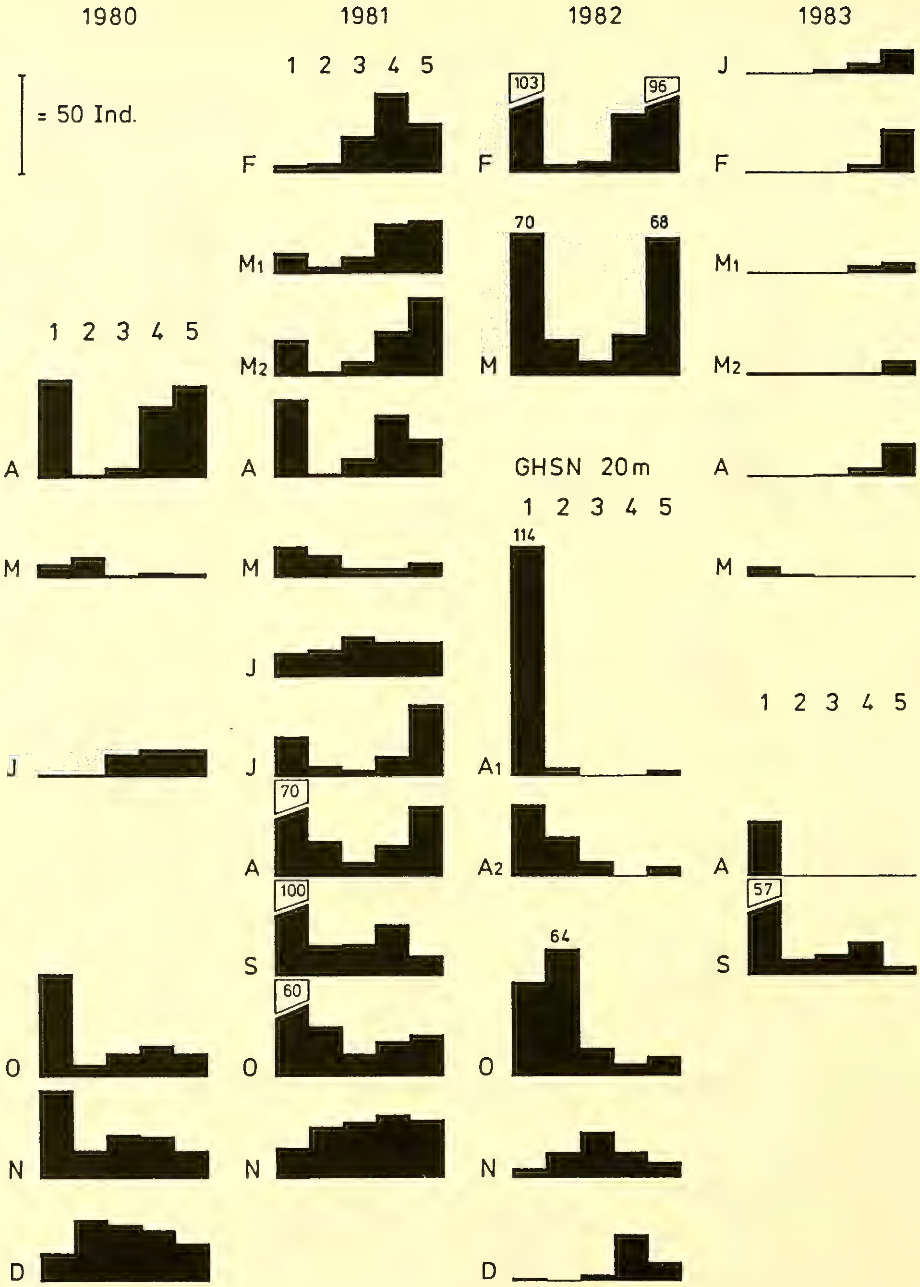

Fig. 4. Distribution of length classes: *Sergentia coracina*.

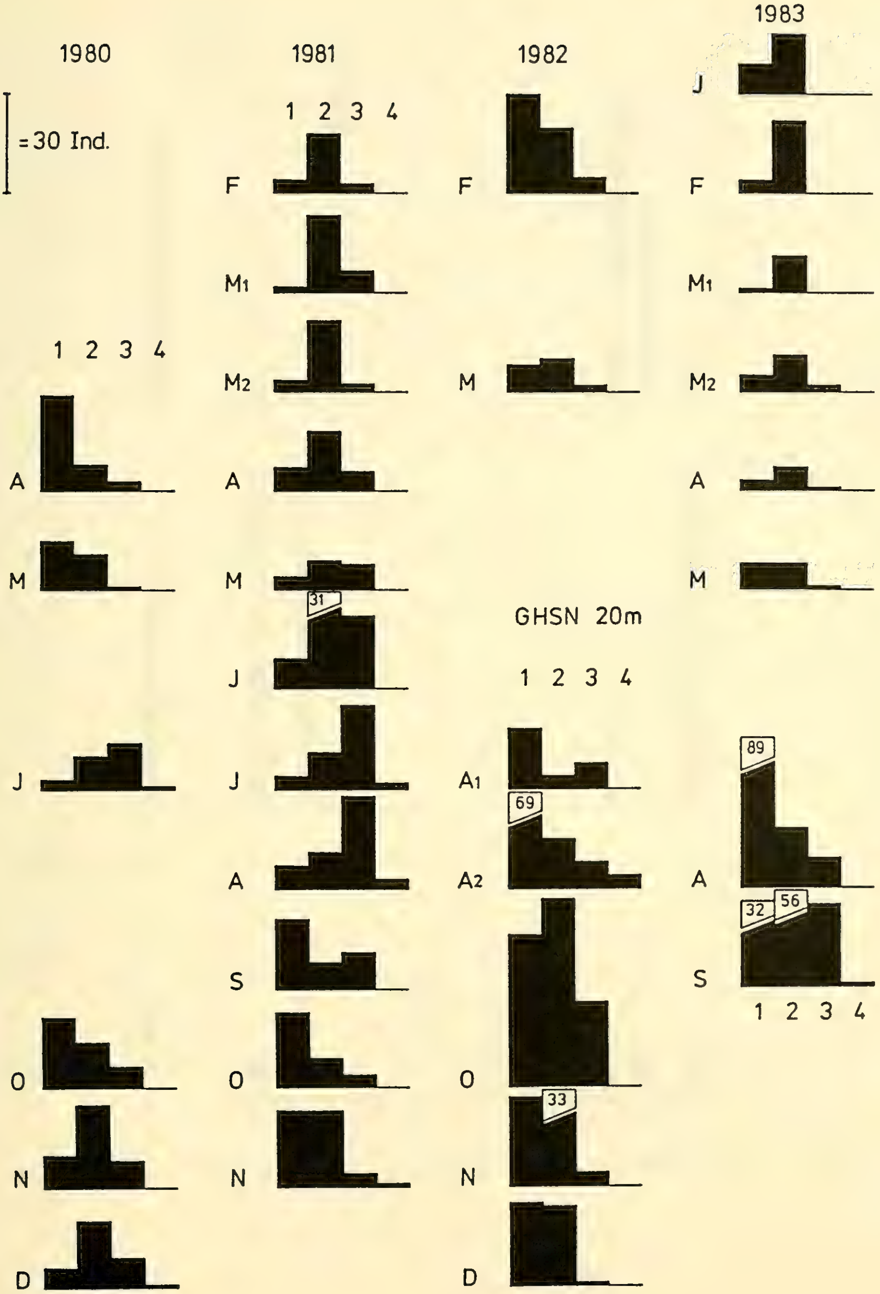

Fig. 5. Distribution of length classes: *Tanytarsus.*

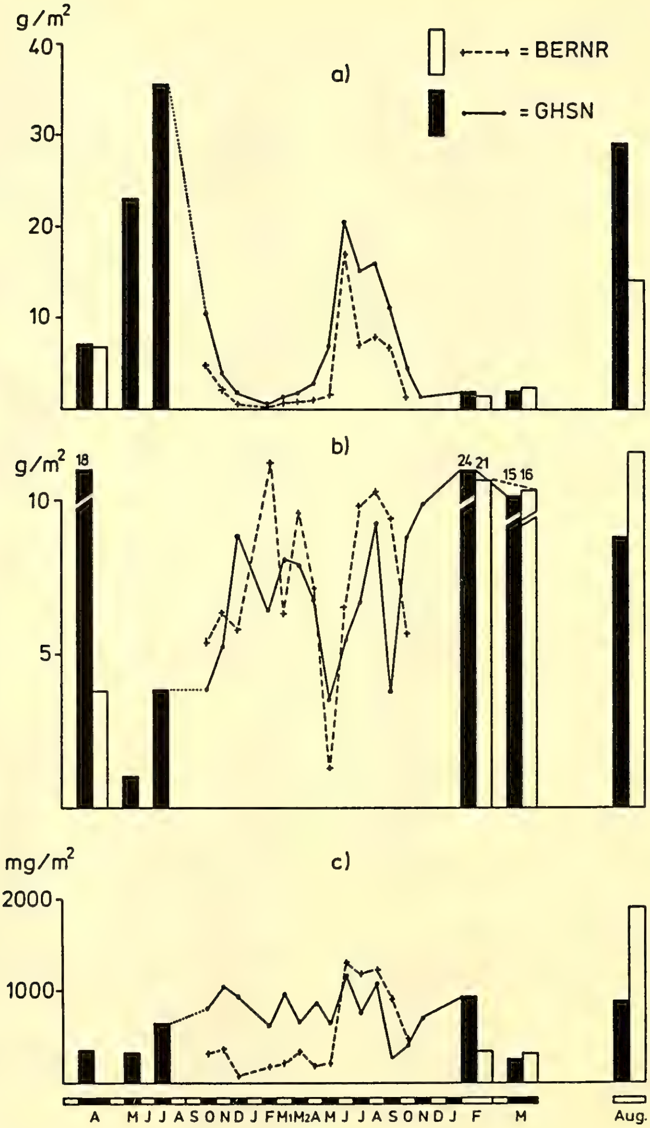

Fig. 6. Annual course of biomass: a) *Micropsectra*, b) *Sergentia coracina*, c) *Tanytarsus*.

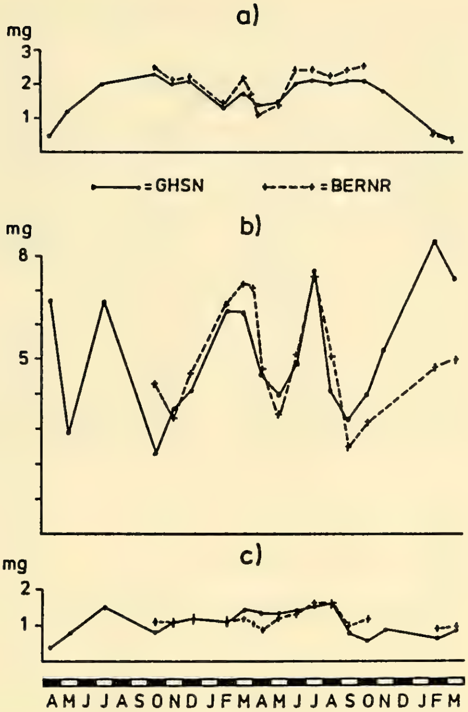

Fig. 7. Average larval weight: a) *Micropsectra*, b) *Sergentia coracina*, c) *Tanytarsus*.

Tab. 1. Length-class criteria of the predominant species.

Length-class	1	2	3	4	5 (mm)
Chironomini:					
Sergentia coracina	0–8.0	8.1–10.0	10.1–12.0	12.1–14.0	>14.0
Tanytarsini:					
Micropsectra spp. *Tanytarsus* spp.	0–5.0	5.1– 7.0	7.1– 9.0	>9.0	–

Tab. 2. b- and m-values for calculation of linear equation.

	G	lnb	b	m	r
Segentia coracina	1	−1.798	0.165	0.274	0.970
Tanytarsini	2	−3.220	0.04	1.860	0.998

G = number of equation, b = y-intercept, m = slope, r = correlation coefficient

Tab. 3. Average larval length (mm) of the 4 larval stages (by means of head capsule width) per depth zone (in parenthesis, the number of individuals measured).

	Micropsectra			*Sergentia*				*Tanytarsus*		
m	II	III	IV	I	II	III	IV	II	III	IV
20	-	4.1 (32)	8.3 (33)	3.4(1)	3.6(147)	7.1(201)	12.9(287)	2.7(14)	3.8(222)	6.1(474)
30	2.6(14)	2.8(314)	8.2 (896)	3.3(1)	3.9 (59)	6.0(440)	13.0(975)	2.5 (3)	3.6 (61)	6.3(307)
40	2.5(30)	2.9(482)	8.3(1320)	2.8(1)	4.0(114)	5.4(464)	12.8(875)	2.6(14)	3.5 (51)	6.5(268)
50	2.6(20)	2.8(207)	8.4(1533)	-	3.9 (40)	5.8(333)	13.6(531)	2.7(27)	3.6 (46)	6.5(173)
60	2.5(13)	2.8(818)	8.3(1537)	2.4(1)	4.0 (19)	5.6 (53)	14.4(153)	2.5 (6)	3.7 (14)	7.2(132)
70	2.7(34)	2.7(583)	8.3(1311)	-	3.5 (1)	6.4 (17)	15.1 (53)	2.5 (5)	4.0 (19)	7.0 (77)
80	2.4 (3)	3.0(269)	8.1 (939)	-	-	7.8 (2)	14.3 (25)	2.5 (5)	3.3 (4)	6.4 (46)
100	2.5 (2)	2.7(306)	8.2 (864)	-	-	7.4 (13)	14.4 (24)	2.5 (4)	3.9 (14)	7.0 (40)
120	-	-	9.3 (23)	-	-	8.5 (2)	14.9 (15)	-	4.0 (3)	6.8 (11)
Ø	2.54	2.81	8.38	2.97	3.82	6.67	13.93	2.56	3.71	6.64

Tab. 4. Calculation of production for *Micropsectra* spp.

Date	$^1/_2(N_t+N_o)$	W_t-W_o (mg)	P (g/m²)	B (g/m²)	
17.04.1980	7969	0.5	3.98	1.7	
29.05.1980	15776	0.7	11.04	23.3	
20.07.1980	16975	0.8	13.58	35.7	
15.10.1980	10739	0.3	3.22	10.5	
07.11.1980	6369	-0.3	-1.91	4.0	
10.12.1980	3610	0.1	3.61	1.6	
		P_{ges}	33.52	B 12.8	P/B = 2.6
10.02.1981	2001	-0.8	-1.60	0.5	
28.02.1981	1348	0.5	0.67	1.1	
16.03.1981	1133	-0.1	-1.13	1.5	
03.04.1981	1566	-0.3	-0.47	2.6	
10.05.1981	3071	0.1	3.07	6.9	
27.06.1981	6624	0.5	3.31	20.5	
31.07.1981	6859	0.1	6.86	15.1	
26.08.1981	7399	-0.1	-7.40	16.1	
23.09.1981	6352	0.1	6.35	11.1	
14.10.1981	4242	0	0	4.5	
23.11.1981	2491	-0.3	-0.75	1.3	
		P_{ges}	8.91	B 7.4	P/B = 1.2

Tab. 5. Calculation of production for *Sergentia* spp.

Date	$^1/_2(N_t+N_o)$	w_t-w_o (mg)	P (g/m^2)	B (g/m^2)	
17.04.1980	1369	6.7	9.17	18.4	
29.05.1980	996	-3.7	-3.68	1.0	
20.07.1980	786	3.7	2.90	3.8	
15.10.1980	1237	-4.4	-5.44	3.8	
07.11.1980	1359	1.3	1.77	5.3	
10.12.1980	1935	0.5	0.97	8.8	
		P_{ges}	5.69	B 6.8	P/B = 0.83
10.02.1981	1579	2.3	3.63	6.4	
28.02.1981	1434	0	0	8.0	
16.03.1981	1339	0	0	7.9	
03.04.1981	1413	-1.8	-2.54	6.7	
10.05.1981	1144	-0.6	-0.69	3.5	
27.06.1981	1134	0.9	1.02	5.5	
31.07.1981	1012	2.7	2.73	6.7	
26.08.1981	1638	-3.5	-5.73	9.3	
23.09.1981	1412	-0.8	-1.13	3.8	
14.10.1981	1809	0.7	1.27	8.8	
23.11.1981	1838	1.3	2.39	9.9	
		P_{ges}	0.95	B 6.9	P/B = 0.14

Tab. 6. Calculation of production for *Tanytarsus* spp.

Date	$^1/_2(N_t+N_o)$	w_t-w_o (mg)	P (mg/m^2)	B (mg/m^2)	
17.04.1980	303	0.6	181.8	335	
29.05.1980	503	0.2	100.6	308	
20.07.1980	459	0.7	321.3	628	
15.10.1980	740	-0.7	-518.0	802	
07.11.1980	844	0.3	253.2	1018	
10.12.1980	825	0.1	82.5	914	
		P_{ges}	421.4	B 667	P/B = 0.63
10.02.1981	764	-0.1	-76.4	605	
28.02.1981	775	0.3	232.5	975	
16.03.1981	654	-0.1	-65.4	643	
03.04.1981	652	0	0	833	
10.05.1981	570	0	0	633	
27.06.1981	706	0.1	70.6	1177	
31.07.1981	605	0.1	60.5	770	
26.08.1981	643	0.1	64.3	1082	
23.09.1981	463	-0.8	-370.4	237	
14.10.1981	580	-0.2	-116.0	396	
23.11.1981	667	0.3	200.1	708	
		P_{ges}	– 0.2	B 733	